Ecological Engineering 70 (2014) 212–216

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

An alternative to field burning of pruning residues in mountain vineyards

Raffaele Spinelli[a,*], Carolina Lombardini[a], Luigi Pari[b], Liana Sadauskiene[c]

[a] CNR IVALSA, Via Madonna del Piano 10, I-50019 Sesto Fiorentino, Italy
[b] CRA ING, Via della Pascolare 16, Monterotondo Scalo (Roma), Italy
[c] Lithuanian Research Centre for Agriculture and Forestry, Liepu 1 LT-53101 Girionys, Kaunas, Lithuania

ARTICLE INFO

Article history:
Received 14 December 2013
Received in revised form 21 April 2014
Accepted 22 May 2014

Keywords:
Baling
Energy
Harvesting
Biomass
Cost

ABSTRACT

The Authors tested a new mini-baler system designed for the recovery of pruning residues in vineyards inaccessible to conventional tractors. Under these conditions, growers manually take the residues to the field edge and burn them there. Such practice is expensive, and generates substantial emissions. Use of the new mini-baler system would substitute burning, with significant advantages on air quality and landscape amenity. The system works well, but productivity is low (mean 0.38 t per scheduled machine hour) and baling cost still too high (mean 80 € t^{-1}). Productivity can be increased and cost decreased through a better preparation of the residues before collection. Farm use of the baled product may dramatically increase value recovery and is facilitated by the availability of newly designed boilers. The versatility and the small purchase cost of the mini-baler makes it an ideal machine for those cases where labour cost is low and investment capacity is limited.

1. Introduction

Vineyards are one of the most adaptable, common and profitable crops in the temperate region. For these reasons, vineyards cover 7.4 million hectares worldwide (FAOSTAT, 2009). Vineyards require annual pruning, which generates a substantial amount of residues, estimated in the range of 1 to 2 t per hectare (Spinelli et al., 2012). Traditionally, pruning residues are disposed through open-air burning, releasing a variety of pollutants (Gonçalves et al., 2011). At a landscape level, agricultural burning generates much less pollution than vehicular traffic (Darley et al., 1966), but localized emissions can be substantial, especially for heavy particulate (Keshtkar and Ashbaugh, 2007). Besides, field burning is labour-intensive and incurs significant cost (Magagnotti et al., 2009). Therefore, finding some use for orchard pruning residues would turn a disposal problem into a collateral production, with a potential for revenues or reduced management costs (Spinelli and Picchi, 2010). In fact, a number of machine manufacturers are now offering dedicated tractor implements for collecting vineyard pruning residues (Recchia et al., 2009, Spinelli et al., 2010). However, use of these machines requires that the vineyards are accessible to tractors, which is a general characteristic of industrial crops. That is not the case of mountain vineyards, often established on steep terrain with very tight spacing (Queiroz et al., 2008). In fact, mountain viticulture is a widespread form of land use, which often yields renowned high-quality wines (Stanchi et al., 2013) representing a typical example of *terroir* (Cross et al., 2011). In this case, high product value is matched by high management costs, derived from the technical constraints typical of mountain environments. Mountain viticulture has the specific landscape, ecosystem and cultural values that define it as a “total human ecosystem” (Naveh and Lieberman, 1984). Under these circumstances, standard mainstream engineering solutions may backfire. Problems must be solved through an integrated multi-functional approach, typical of ecological engineering (Mitsch and Jørgensen, 2003). Extending mechanized residue recovery to these vineyards requires developing a light, cultivator-size machine that can negotiate steep terrain and tight turning space, without causing damage to soil or crop. In 2013, CAEB manufacturing (www.caebinternational.it) designed a small residue baler for mounting on light tracked carriers (Fig. 1). The goal of this study was to determine the productivity, fuel consumption and energy efficiency of this new system, used in a typical mountain vineyard, and to compare the results with the mean cost incurred with traditional field burning. If the new system proved

* Corresponding author. Tel.: +39 055 5225641; fax: +39 055 5225643.
E-mail addresses: spinelli@ivalsa.cnr.it (R. Spinelli), lombardini@ivalsa.cnr.it (C. Lombardini), luigi.pari@entecra.it (L. Pari), lsadauskiene@gmail.com (L. Sadauskiene).

http://dx.doi.org/10.1016/j.ecoleng.2014.05.023

Fig. 1. The minibaler at work.

functional and cost-effective, it would represent a viable option for the disposal of pruning residues in mountain vineyards using a cleaner and safer method than field burning, and without needing a radical change of crop establishment and management techniques.

2. Materials

The test was conducted in March 2013 near Sondrio, in Northern Italy. Sondrio is located in Valtellina, where Nebbiolo grapes have been grown on terraced hills and cliffs since Carolingian times (900 AD). Maximum expansion was reached in the 19th century, when viticulture covered over 6000 ha, located on the hillsides (25%) and on the alluvial plain (75%). After World War II, urbanization and industrial farming occupied most of the plain and the alluvial deposits, where the terrain was flat or moderately inclined. At present, the largest majority of the approximately 2000 ha of vineyards are located on the steepest ground, on man-made terraces, which are generally inaccessible to tractors (De Lorenzis et al., 2012). Modern mechanisation is needed and it may be key for the survival of a valuable cultural landscape. For the purpose of the study, we selected 12 different fields. These were located in different areas and were meant to represent the full range of conditions encountered in Valtellina vineyards. Field characteristics are shown in Table 1, and are characterized by narrow interrow spacing, ranging from 1.8 to 2.9 m. Furthermore, maneuvering space at the field edges was quite tight (<5 m), since the fields were often enclosed by retaining walls.

The machine used for the trials was the new CAEB 730 CNG minibaler, mounted on a Camisa TP 680 mini-dumper (www.fratellicamisa.it). The TP680 is a carrier powered by a Subaru 10 kW diesel engine and travels on rubber tracks. Machine width is limited to 1.2 m, which allows easy access into tightly spaced vineyards. The total weight of the carrier and the attachment was 1000 kg. The same operator ran the machine for the duration of the trial. This was CAEB's test driver, who had tested CAEB machines for many years and had much experience with the operation of pruning residue balers.

3. Methods

The study was designed to evaluate system productivity and to identify the most significant variables affecting it. The data collection procedure consisted of a set of detailed time and motion studies conducted at the cycle level, where the harvesting of one bale was considered as a complete cycle.

Time consumption was split into time elements considered to be typical of the functional process analyzed, and consisted of harvesting the residues, dumping the bale, turning, driving in and out and delays. This was done with the intent of isolating those parts of the routine that took longer or were especially problematic, so as to target future improvements. All time elements and the related time–motion data were recorded with Husky Hunter® hand-held field computers running Siwork3® time-study software. Time study sessions lasted a total of 11.5 h.

Mass output was determined by individually scaling all bales produced during the tests, using portable scales. Moisture content was determined on three samples per plot, according to European standard CEN/TS 14774-2.

Row spacing was measured with a tape, whereas the length of row harvested for each run and the distance covered while moving the loads to the collection point were measured with a hip chain. Harvested area was measured with a commercial-grade GPS device. Harvesting losses were estimated on one sample per plot. The sample was obtained by manually collecting all the pruning residues left on the area that had previously yielded one randomly selected bale. Percent losses were then estimated as the ratio of remaining residue weight to bale weight, for each sample. Fuel consumption was estimated by starting each work day with a full tank and refilling the tank at the end of the day. This occurred for three consecutive days. Fuel consumption was related to the hours worked each day.

Table 1
Characteristics of the test fields.

Field (no.)	Placename	Area (m^2)	Slope (%)	Rows (n°)	Interrow width (m)	Bales (n°)	Stock (t ha^{-1})	m.c. (%)	Stock (odt ha^{-1})	Losses (%)
1	San Lorenzo	1215	8	8.5	1.9	31	4.3	46.9	2.3	13
2	San Lorenzo	1280	4	11.5	1.8	25	3.4	46.9	1.8	13
3	San Lorenzo	464	7	3.0	1.8	5	2.1	46.9	1.1	13
4	La Priora	1698	15	8.0	2.9	15	1.7	40.0	1.0	28
5	La Priora	1036	18	12.0	2.9	9	1.6	40.0	1.0	27
6	Morella	955	10	7.0	2.2	17	3.0	47.3	1.6	20
7	Morella	1266	12	8.0	2.4	25	3.6	45.6	2.0	21
8	San Lorenzo	428	5	7.5	2.0	10	3.5	45.1	1.9	16
9	San Lorenzo	761	7	11.0	1.9	18	3.5	45.1	1.9	7
10	San Lorenzo	945	5	5.5	1.8	26	4.0	45.1	2.2	16
11	Singelle	1090	3	6.0	2.6	24	3.3	41.7	2.0	14
12	Sighezzon	2114	3	11.5	1.9	46	3.2	48.4	1.7	21
	Mean	1104	8	8.3	2.2	21	3.1	44.9	1.7	17
	Total	14,356		107.8		272				

Notes: m.c—moisture content; odt—oven-dry tonnes.